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Climate change characterisation and planning in large tropical and subtropical cities

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2 Climate Change Characterisation and Planning in Large Tropical and Subtropical Cities[5]

Abstract: In recent years, the number of large subtropical and tropical cities with defined climate plans has increased as a result of the initiatives of local governments, multi-bilateral development aid and development banks. Surveys carried out to date on climate planning consider the overall cities, at times by continent, without underscoring those that present planning deficiencies. For instance, we have no idea whether the cities that are most affected by hydro-meteorological and climatic disasters have plans, nor if their climate plans are ready to be implemented. Clarifying these aspects would strengthen the foundation of the current discussion on the United Nations' Sustainable Development Goals 2016–2030. Hence, the objective of this chapter is to ascertain the relevance and quality of climate planning in large subtropical and tropical cities populated by over 1 million inhabitants. Our survey found 344 large cities in the two climate zones concerned, and 82 of these have mitigation, adaptation, resilience or emergency plans, strategies or policies. We verified the relevance of these tools for the climate zones concerned, the type of economy and the frequency of hydro-meteorological and climate-related disasters. The quality of plans was assessed, ensuring that they had taken climate characterisation into account, that every measure was managed by a designated agency or office, and that funds were secured for implementing measures, as well as a monitoring and reporting sytem was defined.

The analysis of collected information underscores considerable differences between large cities in terms of per capita greenhouse gas emissions (which were double in the subtropics relative to the tropics) and exposure to hazards (which were greater in the subtropical zone). Emergency and mitigation plans were the most common, while adaptation plans and resilience strategies were more unusual. The relevance of plans is still weak, given that barely 1/4 of the large cities had a plan. Plans were unquestionably more common in the subtropics, especially in OECD countries and in the BRICS, while they were absent in the Least Developed Countries (LDCs), despite the

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presence of large cities that have been repeatedly affected by hydro-meteorological and climate-related disasters. Planning quality was good for 30% of cities only. In the remaining 70% of cities, climate characterisation was briefly defined; the planning process was fully funded by multi-bilateral development aid; measures were without a clear manager; cost, funds and monitoring of measures were not specified. Thus the indication being that local plans were still scarcely action-oriented. Hence, the fact that two sustainable development goals (# 11 and 13) address human settlements and climate change, respectively, especially through assistance to LCDs, seems justified.

Key words: Climate change, Climate-related disasters, Emergency plan, Mitigation plan, Adaptation action plan, Resilience strategy, Subtropics, Tropics, Large cities

2.1 Introduction

Climate change (CC) “refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or by the variability of its properties, and that persists for an extended period, typically decades or longer” (IPCC 2014: 5). One of the most dominant drivers for CC is the concentration of greenhouse gases (GHG) in the atmosphere that alters the energy balance of the climate system. Carbon dioxide (CO_2) is the primary GHG responsible for CC, and it is mainly produced by burning fossil fuels and deforestation. Large cities (with over one million inhabitants) are responsible for GHG emissions, since they are heavily reliant on fossil fuel consumption to produce energy. Urban areas account for between 49% and 76% of CO_2 emissions from global final energy use. (Marcotullio *et al.* 2013; Seto *et al.* 2014).

The climate in large cities is also closely related to spatial configuration, density, topography and land cover, all factors that can modify temperature, humidity, precipitation as well as wind and air quality (Alcoforado *et al.* 2010). When extreme winter temperatures, droughts, floods, heat waves, landslides, storms and wild fires affect large cities, their impact is devastating if the cities are not well prepared, due to population density and the concentration of economic activities (McClean 2010; UN-Habitat 2009, 2011).

However, large cities also concentrate resources to reduce the impact of CC by adopting appropriate measures. Actually, a growing number of large cities is defining plans to reduce emissions that cause global warming in order to adapt to CC and withstand the consequences of any natural disasters. This mobilisation arises from the initiatives of several multilateral bodies (multilateral development banks, UN-Habitat, UNESCO, UNISDR, WHO, WMO), bilateral aid, associations and movements of local governments (ICLEI, C40, Covenant of Mayors), and commitments made by individual countries in the framework of international agreements (UNFCCC, HFA). These commitments are often converted into national laws that enforce local climate planning.

Past surveys on climate planning (Vergara 2005; CAI 2012; Carmin, Nadkami and Rhie 2012; Fraser 2012; CDP 2014) consider the overall cities, at times analysing them by continent, without distinguishing between towns and mega cities, tropical and temperate or boreal settlements, least developed countries and wealthiest economies. This fails to provide information about the extent of planning in cities that are most exposed to hydro-meteorological and climate-related disasters or in the largest ones, or the quality of the plans. Since the first generation of plans presented poor quality (Preston *et al.* 2011; Tang *et al.* 2010), this issue seems important for the current discussion on Sustainable Development Goals 2016–2030, where access to safe housing, the reduction of affected people and decrease in economic losses caused by disasters (UN 2014) are accepted as targets.

Hence, the objective of this chapter is to ascertain the relevance of climate plans and their quality.

We first defined two climate zones that contain half the urban population of the World and record the major hydro-meteorological and climate-related disasters, namely the subtropics and the tropics. The former includes large cities of countries that have joined the Organisation for Economic Co-operation and Development (OECD), such as Australia, Chile, France, Greece, Israel, Italy, Japan, Mexico, Portugal, South Korea, Spain, Turkey, United States, and the five BRICS (Brazil, Russia, India, China, South Africa). The tropics include parts of OECD and BRICS countries as well, but especially large cities in Developing Countries and Least Developed Countries (LDCs). This distinction must be taken into account when we consider adaptation measures that, besides responding to specific hazards presented by single climate zones, are funded consistently with the expansion capacity and model of the city, which are typical of the various economies.

Within each climate zone we first defined cities that are populated by over 1 million inhabitants (344) and then, among these, the ones that have enforced climate planning tool (82).

We then defined the types of plans, their relevance (by climate zone, by country and related to the frequency of disasters), and quality (implementation features and implementation control program).

The chapter is organized as follows: (i) the emergence and dissemination of climate planning, the types of plans, the measures, and the quality of climate plans, (ii) the general significance of the results achieved, and (iii) the recommendations.

2.2 Materials and Methods

Climate plans can be explored by contacting local administrations (Carmin, Nadkami and Rhie 2012; Baker *et al.* 2012), examining the plans (Corell *et al.* 2007; Birkmann *et al.* 2010; Preston *et al.* 2011), or by adopting both methods (Wheeler 2008; Bassett *et al.* 2010, GIZ-ICLEI 2012). This chapter is based on the second method. Its original approach, compared to previous surveys, can be found in three aspects, namely (i) narrowing the investigation to a homogeneous group of cities in terms of climate zone (subtropical and tropical) and number of inhabitants (over 1 million), (ii) comparison between cities that have a plan, versus those affected by hydro-meteorological and climate-related disasters during the past decade, (iii) the quality of plans.

The two climate zones were defined with Köeppen-Geiger's classification based on temperatures and rainfall observed over the period 1971–2000 (Rubel and Kottok 2010) on one 0.5 degree latitude/longitude regular grid, as presented on the website http://koeppen-geiger.wu-wien.ac.at/shifts.htm (Figure 2.1). Categories and subcategories were used according to Trewartha's classification (Belda *et al.* 2014), which is adopted by the FAO, the Joint Research Centre of the European Commission and by IPCC (www.fao.org/docrep006/ad6528/ad652e07.htm). The subtropical zone includes the categories dry summer Mediterranean, humid and dry winter, and the tropical one includes the categories wet-tropical rain forest, tropical wet in dry called savanna, subtropical desert, subtropical steppe.

Cities with over one million inhabitants were identified from the last census or projections of national demographic services. The geographical coordinates of every city were considered in order to choose those located within the subtropical (196) or tropical (148) zone.

A review of the literature helped to determine whether these cities had a strategy, a policy, or a plan. And if they did, the tool was downloaded from the city council's website. At times, the plans mentioned by the literature were either offline or not even mentioned in municipal documents that were accessible online. In the latter case, we did not consider the plan. Exclusion arises from the assumption that a plan must be public, especially if it is designed to involve stakeholders and when it appeals to the contribution of a broad range of local actors for its implementation.

Local governments with less than one million inhabitants were not considered, unless the plan concerned a supramunicipal jurisdiction (metropolitan area), such as Hyderabad, India, Lagos, Miami, Montevideo, Naples, Sydney and Turin, all of which had over one million inhabitants. This led to the exclusion of San Francisco, one of the first subtropical cities to define a climate action plan, as well as Melbourne and Perth. Plans that were in the process of being drawn up were not considered.

After the plans were collected, their relevance was assessed by comparing such planned cities against the ones listed in the EM-DAT database of the Centre for Research on the Epidemiology of Disasters (CRED), which records hydrological (general flood, flash flood, coastal flood, landslide), meteorological (tropical cyclone, local storm) and climate-related (drought, extreme winter conditions, heat wave, forest or scrub fires) disasters. The 283 disasters recorded between 2005 and 2014 were probably fewer than the ones that actually affected large subtropical and tropical cities during the past decade, since we did not consider disasters that affected the states and regions to which these cities belong, due to the existence of very vast ter-

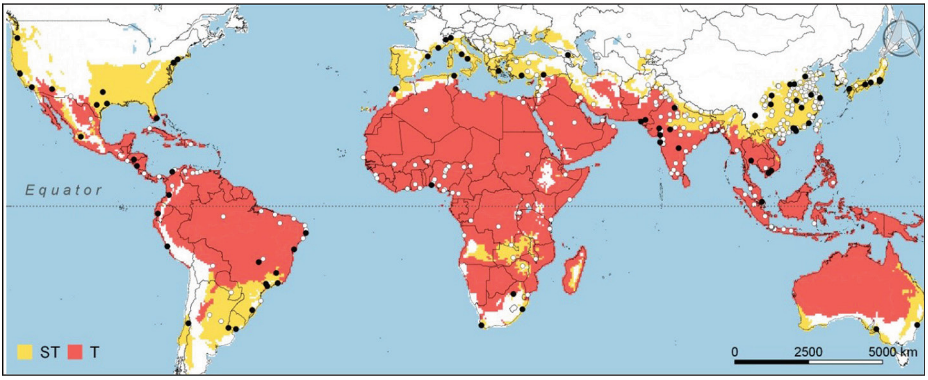

Figure 2.1: Subtropics (ST) and Tropics (T), 2014. Large cities provided by a mitigation and adaptation plan or strategy or an emergency/contingency plan (black dot) and without plan (circlet) (by S. Braccio).

ritories in which the disaster might only have grazed the urban area in question. This is often the case in Brazil, China, India and the USA.

The analysis of cities also took into account two aspects that are at the root of climate planning. First, we considered the amount of per capita GHG emissions, as estimated by emission inventories completed either prior to or concurrently with the climate planning process. Toward this end, we collected a total number of 48 GHG inventories. These inventories were produced with heterogeneous methods, but, until new ones are defined consistently with the COP20 protocol established in Lima (WRI 2014), they remain the only source of information to analyse the CO_2 emissions of such a considerable number of large cities. Secondly, we considered studies on the hydro-meteorological and climatic hazards that threaten cities. This information is also gleaned from climate plans.

2.3 Results and Discussion

2.3.1 Emergence and Dissemination of Climate Planning

Reducing the impact of CC entails (i) reducing the causes thereof, (ii) protecting the population and assets exposed both before and (iii) during a hydro-meteorological or climate-related disaster.

In 70% of the cases examined, the local governments planned these activities as the application of specific national or regional laws, as in the case of the Global Warming Solutions Act of California (2006). In the remaining cases, they do so after signing the US Conference of Mayors' Climate Protection Agreement (2005), the Covenant of Mayors (2008) or other unilateral initiatives to reduce the risk (Table 1.1). Autonomous planning initiatives that are foreign to national or state trends or to the influence of multilateral bodies, such as the ones underscored a few years ago in Quito and Durban (Carmin, Roberts and Anguelovski 2012), seem to be less feasible today.

Table 2.1: Large subtropical and tropical cities, 2015. Legal framework for 44 local climate planning tools.

Large city	Type of plan	Not specified	Supra-national	National/ Federal Law	Local government Act	State/ Regional Law	Local Law
Adelaide	A					•	
Ahmedabad		•					
Buenos Aires	MA		•				
Bangkok	M		•				
Barcelona	M		•				
Belo Horizonte	M		•				•
Cape Town	M			•			
Cartagena	A	•					
Casablanca	A	•					
Chongquing	E/C			•			
Durban	S						
Ganztiep	M			•			
Guayaquil	A	•					
Ho Chi Minh	A	•					
Houston	M	•					
Indore	S	•					
Karachi	S	•					
Kobe	M			2011			
Lagos	P			1999			
Los Angeles	MA	•					
Marseille	MA			2010			
Miami	M	•					
Milan city	M		•				
Milan metro	E/C					2004	
Montevideo	MA			•			
Mumbai	E/C			2005			
Nanjing	E/C			2014			

continued **Table 2.1:** Large subtropical and tropical cities, 2015. Legal framework for 44 local climate planning tools.

Large city	Type of plan	Not specified	Supra-national	National/ Federal Law	Local government Act	State/ Regional Law	Local Law
Nagoya	OP			•			
Naples	E/C					•	
Philadelphia	MA	•		2000			
Phoenix	M					•	
Portland	M				2007		
Porto Alegre	E/C						•
Recife	S			•			
Rio de Janeiro	S	•					
Rome city	M		•				
Rome metro	E/C				1998		
Salvador de Bahia	E/C			2012			2013
San Antonio	E/C		2000				
San José	S					•	
Santiago de Cali	E/C			1989			
São Paulo	MA	•					
Shenzhen	MA			•	•		
Singapore	M		•				
Surat	S		•				
Tegucigalpa	E/C			1993	•		
Tbilisi	M		•				
Tokyo	M	•					
Tunis	A	•					

*Kyoto protocol, Convenant of Mayors, Asian Cities Climate Change Resilience Network, US Conference of Mayors, USA HMA 2000.

A mitigation action is “a human intervention to reduce the sources or enhance the sinks of greenhouse gases” (IPCC 2014: 19). Mitigation planning is the most common climate tool in subtropical and tropical cities, as it is the outcome of long-term actions implemented by local government organisations, such as ICLEI (from 1991, over 1,000 members), C40 (from 2006, 75 members) and by movements like the Covenant of Mayors (from 2008, 5,881 participants), dedicated funds of Mulitlateral Development Banks (MDB) and of certain foundations (1,100 M US$ at the ADB, 140 million US$ from the Rockefeller Foundation and other partners). It also issues from dissemination of knowledge, and from pilot programs launched by the IPPC and other multilateral and bilateral bodies. The first mitigation plans for subtropical large cities were defined in the USA (Los Angeles, Philadelphia 2007), and this trend was rapidly adopted in Asia, South Africa, Latin America and Europe. They focus on reducing emissions in the sectors of transportation, commerce and industry, the residential sector as well as the field of waste collection and disposal by introducing changes that are at times very costly.

Adaptation planning focuses on "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (UNISDR 2009). Plans include non-structural measures (e.g. early warnings, flood drills) and structural measures (flood barriers, stormwater drainage, and resettlement of inhabitants from flood-prone areas). In the latter case, if local adaptation plans are not expressly envisaged by the general environment protection law (Uruguay) or by a specific national law (Philippines 2007), they are implicit in the Local Government Act of various countries (Australia 1999, South Africa 2000, Peru) when council functions are specified and often extended to "protect its area from natural hazards and to mitigate the effects of such hazards." In other cases (Argentina), the individual cities implement the specific national commitments made at the United Nations Framework Conference for Climate Change (UNFCCC). Adaptation planning is funded by dedicated MDB programmes, but is still scarcely practised as it has not been able to be implemented on the same global mobilisation levels as GHG mitigation.

Emergency or contingency planning is a "management process that analyses specific potential events or emerging situations that might threaten society or the environment, and establishes arrangements in advance to enable timely, effective and appropriate responses to such events and situations" (UNISDR 2009: 7). Once again, a national law envisages the disaster prevention device (Chile, China, Colombia, India, Philippines, etc.) or civil defence (Brazil), and subsequently the creation of municipal emergency committees to draw up dedicated plans. In other cases (Texas), the contingency plan is drawn up in compliance with rules defined by state commissions. Emergency planning is a very common practice. Several cities have committed to implement it by adhering to various declarations, the last of which is the Aqaba Declaration (2013).

Resilience strategies are the ultimate planning tool. They focus on strengthening the "ability of a community exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic infrastructures and functions" (UNISDR 2009: 24). Since 2010, UNISDR has supported local resilience strategies, especially partnered in Asia by the Rockefeller foundation. The target of

Table 2.2: Large subtropical and tropical cities, 2005–2014. Incidence of hydro-meteorological and climate-related disasters, and establishing climate planning (source: EM-DAT and Survey by M. Tiepolo).

Large cities (> 1 M inhabitants)	Nº	%
Affected by natural disasters 2005–2014	122	42
Idem, with plan	45	
Not affected by natural disasters 2005–2014	170	58
Idem, with plan	11	
Total affected	292	100
Idem, with plan	50	

these strategies is to strengthen planning, organisational and management skills in view of a disaster, rather than implementing structural measures.

At least 82 large cities have a climate planning tool today (Figure 1.1). Five of them have both a mitigation/adaptation or resilience plan as well as an emergency plan. Two thirds of the cities are subtropical. Sixty-six cities belong to the most developed economies (OECD) or to rapidly developing ones (BRICS), and only sixteen are situated in Developing Countries. Seventeen cities are Chinese, eight are in the United States and eight are European.

During the past five years, climate plans in large subtropical and tropical cities have increased by 150% compared to 2010; to be precise, 48 new plans have been added to the 33 existing at the time. Another 10 plans are being drawn up, basically in the subtropics, particularly in OECD and BRICS countries, namely Abu Dhabi, Algers, Bangkok, Curitiba, Fortaleza, Kathmandu, Porto Alégre, Rio de Janeiro, San Antonio (TX), San José (CA). Large LCD cities are still excluded.

However, 262 millionaire cities (76% of the total) still lack planning tools to face CC, even though they are not spared from hydro-meteorological and climate-related disasters. According to the EM-DAT database, 43 subtropical and tropical cities that were repeatedly affected by disasters during the past decade still lack a plan, including Quezon city-Manila (7 disasters during the past decade), Dakar, Havana, Luanda (5), Brazzaville, Managua, Maputo, Ndjamena, Niamey, Santo Domingo (4).

2.3.2 Tool Types and Their Characteristics

Large subtropical and tropical cities have strategies (10%), policies (1%) and plans (89%).

The strategy "refers to a general plan of action for addressing the impacts of CC, including climate variability and extremes. It may include a mix of policies and measures, selected to meet the overarching objective of reducing the vulnerability" (Lim *et al.* 2004: 250). The mitigation strategy starts from the emissions baseline, which is at times calculated by sector (transportation, commerce, industry, residence, waste), and is organised in initiatives, each of which lists the principal actions, without either localising them or specifying the expected results in terms of reducing emissions and, even less so, costs and funding modes (Tokyo) (Table 2.3). Some Brazilian cities have defined a mitigation policy (Belo Horizonte, Recife), that indicates the tools a city must have (plans, programmes), the initiatives to be pursued (renewable energies, compact city, strategic environmental assessment of plans, protection of biomasses that can reduce GHGs), and establishes the general and specific goal (e.g. percentage of emissions to be reduced over a period of time). The policy indicates mitigation and adaptation measures without localising them, namely transportation, energy, waste, health, construction works, land use, high risk buildings, permanent protection areas, maintenance of permeable surfaces, and forestation. The policy then indicates the implementation tools (annual report on emissions, tax reductions if renewable energies are used, reduction of GHG emissions/absorption, contributions to private reserves of natural heritage, training programmes, devices to reduce the GH effect, CO_2 market, civil defence, early warning system for extreme events, and CC municipal committee).

Table 2.3: Large subtropical and tropical cities. Localisation and impact of measures envisaged by 33 climate plans.

Large city	Zone	Plan type	Baseline	Goals	Options priorities	Measures		
						Localization	Impact mitigation potential	Scheduling
Adelaide	ST	A				occasional		
Antalya	ST	M	•	•		occasional	•	•
Bangkok	T	M				occasional	•	
Barcelona	ST	M						
Belo Horizonte	T	M	•	•			•	
Buenos Aires	ST	MA					•	
Cape Town	ST	M					occasional	
Cartagena	T	A						
Casablanca	ST	A				•	•	•
Durban	ST	A						

continued **Table 2.3:** Large subtropical and tropical cities. Localisation and impact of measures envisaged by 33 climate plans.

Large city	**Zone**	**Plan type**	**Baseline**	**Goals**	**Options priorities**	**Measures**		
						Localiza-tion	**Impact mitigation potential**	**Scheduling**
Gaziantep	ST	M					generic	
Guayaquil	T	A						
Houston	ST	M					•	
Los Angeles	ST	M						
Marseille	ST	MA						
Miami	T	M					•	
Milan city	ST	M	•	•			•	
Montevideo	ST	MA						
Naples	ST	M	•					
New York City	ST	A				•		
Philadelphia	ST	M					•	
Phoenix	T	M					•	
Portland	ST	M						
Rio de Janeiro	T	R						
Rome city	ST	M	•	•			•	
San José	ST	M					•	
Saitama	ST	M						
São Paolo	ST	MA		•				
Santiago Chile	ST	A						
Semarang	T	A						
Tbilisi	ST	M					•	
Tunis	ST	A				•		•
Zapopan	ST							
Total			5	5	0	6	15	3

In the best cases, plans localise the measures, describe them in detail, estimate the cost, define the lead city agency and funding sources, thus specifying priorities and the monitoring, evaluation and reporting program.

2.3.2.1 Mitigation

This group collects 25% of the planning tools traced. The prevalence of mitigation confirms the observations of Revi, Satterthwaite *et al.* (2014). Mitigation plans in subtropical zones are conceived in the USA, and usually comprise the emission inventory, GHG reduction goals and measures. The most detailed plans estimate the expected reduction of emissions, the risks resulting from CC, the cost, funding sources and the timing of every measure. The capability assessment, which considers the technical and political ability to implement the measures, is rarely conducted.

The GHG emission inventory of 48 subtropical and tropical large cities underscores the fact that per capita emissions indicate a mean value of 6.2 T (Table 2.4). But the value is more than two-fold in the subtropics (8 T) relative to the tropics (3.5 T). The first sector for emissions is transportation and the second is industry in both zones, while the residential sector (the considerable seasonal temperature variation demands heating and cooling) ranks third in the subtropics, and commerce ranks third in the tropics (where heating is not required and often households can't afford cooling costs). There are no direct relations between the demographic size of the city and per capita GHG emissions.

Table 2.4: Large subtropical and tropical cities. Total GHG emissions according to 48 plans detailed by sector (39 plans).

Climatic zone	GHG emissions*							GHG**	P**	GHG/pc
	Transport	Commerce	Industry	Residential	Waste	Other	Total	Total		
	%	%	%	%	%		MT	MT	Millions	T
Subtropical	29	13	24	22	3	3	594	1275	160	8.0
Tropical	30	6	28	6	4	3	176	348	100	3.5
ST & T	29	11	24	18	3	3	770	1623	260	6.2

*39 plans, **48 plans

2.3.2.2 Adaptation

Adaptation plans (11%) usually describe the consequences of CC in terms of expected hazards (temperatures, rainfall, etc.). Then they define the expected impact (vulnerability), which is rarely analysed in terms of risk (hazard probability* expected damage). Areas exposed to the greatest impact are often highlighted on maps to facilitate the definition of measures to be implemented. Adaptation plans then define the objectives and intervention axes. Usually, the measures are described with charts that also specify priority, temporal distribution and who must implement them. Adaptation plans rarely specify performance indicators and the monitoring and reporting

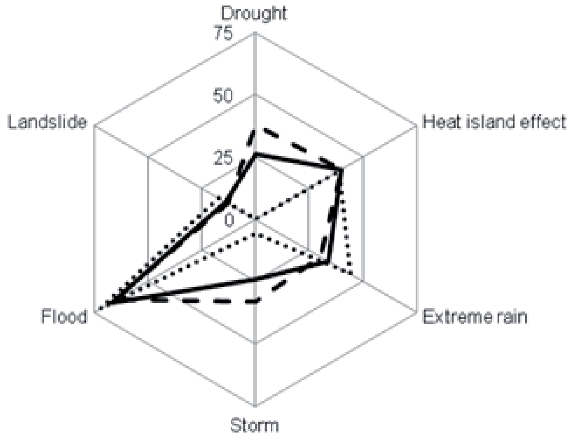

Figure 2.2: Large subtropical and tropical cities. Frequency (%) of main hazards mentioned in plans.

program (Table 2.3). The adaptation plans of large subtropical and tropical cities differ in terms of the hazards they must face. A study of 23 climate plans underscores the fact that the increased incidence of floods (generated by river or by sea level rise) is the hazard that is most cited as a consequence of climate change (61% of plans mentions them), followed by heat waves (52%), extreme rainfalls (30%), drought (30%) and storms (22%) and, with a lower incidence, landslides, snow and fire. But subtropical cities are exposed to a larger number of hazards than tropical ones. Secondly, subtropical cities feature drought, storms (hurricanes, cyclones) and extreme rain, while tropical cities are not affected by drought and storms are less frequent (Figure 2.2, Table 2.5).

2.3.2.3 Resilience

Resilience strategies (6%) are especially common in Asia, and only concern large tropical cities for the time being. Aside from structural measures, they define many actions based on accumulation of information (databases on hazards, hazard prone areas identification), management (establishing a CC coordination office), training and awareness sectors. The most accurate resilience strategies identify vulnerabilities, list the actions required to reduce them, define implementation phases and the relevant financial mechanism.

2.3.2.4 Emergency/Contingency

This group (40%) is especially common in Europe, Latin America and China but not in Africa, with the exception of South Africa. Sixty-one percent of plans traced were drawn up over the past three years. There are two types of plans, ones that specify

Table 2.5: Large subtropical and tropical cities. Main hazards according to 23 climate plans.

Large city	Zone	Plan	Hydrological		Meteorological		Climatic				
			Flood	Land slide	Intense rain	Storm	Drought	Cold	Snow	Heat wave	Fire
Adelaide	ST	A			•					•	•
Bangkok	T	M	•								
Barcelona	ST	M								•	
Buenos Aires	ST	MA	•		•					•	
Cape Town	ST	M	•		•						
Cartagena	T	A	•				•				
Casablanca	ST	A									
Durban	ST	A	•			•				•	
Los Angeles	ST	M	•				•			•	
Marseille	ST	MA			•		•			•	
Miami	T	M	•								
Milan city	ST	M									
Montevideo	ST	MA			•	•	•			•	
Naples	ST	M	•	•							
New York City			•		•	•	•			•	
Philadelphia	ST	M	•			•			•		
Phoenix	T	M								•	
Rio de Janeiro	T	R									
Rome city	ST	M	•								
Saitama	ST	M								•	
Santiago Chile	ST	A	•							•	
São Paolo	ST	MA	•		•	•	•			•	
Tunis	ST	A	•				•				
Total			14	1	7	5	7	0	1	12	1

the arrangements a local government must make in order to become operative in case of a disaster (Cape Town, Tshwane), and operative ones (Milan, Naples, Rome, San Antonio, Santiago de Cali, Turin), which describe the sequence of established operations the various actors are called upon to implement in order to respond to the emergency. These plans are, at times, limited to only one hazard (drought in Campinas and Dallas, floods in Jinan, Luoyang and Zhangjiagang) (Table 2.6). Though they do not solely refer to CC-related disasters, they overlap mitigation/adaptation plans with respect to the definition of zones that are either exposed or at risk. In cities that have both an emergency plan and an adaptation plan, the two tools refer to different bodies, specifically civil defence or fire brigade in the first case, city council/environmental sector in the second one. The plan is implemented after an early warning. The warning should be strategically communicated to areas that are exposed to the hazard, especially in case of floods. This only occurs in 30% of cases. However, only 18% of plans define the threshold of early warning, barely 20% define hazard prone areas and only in half the cases do they make use of maps.

The emergency plans of large cities in tropical zones better define the pre-emergency phase by describing the hazard prone areas (40%) and the early warning system (60%) more often. Conversely, those of large subtropical cities better detail the emergency phase by reporting the guidelines for potentially affected populations (30%), defining escape routes (20%) and emergency refuges (30%) that are virtually absent in tropical zones (Table 2.6).

Table 2.6: Large subtropical and tropical cities. Choice of 31 emergency/contingency plans.

Large city	Zone	Flood	Land/Mud slide	Heavy rain	Storm	Wind	Drought	Cold	Snow	Heat	Fire	Thunderstorm	Tsunami	EWS	EW level	Hazard prone areas	Losses	Guidelines to people business	Escape routes	Emergency refuge location
Ahmedabad	T									•				•						
Bazhong	ST								•											
Campinas	ST						•				•			•						
Cape Town	ST																			
Dallas city							•							**						-
Delhi	T	•												•						
Fukuoka	ST	•	•	•		•														
Hong Kong	T	•	•		•							•	•	•						
Hyderabad, PAK	T	•		•										•	T	•				•
Jinan	ST	•	•				•													
Lima	T	•	•													map				
Luoyang	ST	•													P					

continued **Table 2.6:** Large subtropical and tropical cities. Choice of 31 emergency/contingency plans.

Large city	Zone	Flood	Land/Mud slide	Heavy rain	Storm	Wind	Drought	Cold	Snow	Heat	Fire	Thunderstorm	Tsunami	EWS	EW level	Hazard prone areas	Losses	Guidelines to people business	Escape routes	Emergency refuge location
Milan	ST	•			•	•		•	•						SW					map
Mumbai	T	•														list				list
Nanchang	ST	•			•	•	•									map				list
Nanjing	ST	•	•	•			•		•		•			•		map				map
Naples	ST	•	•	•											P	map/ list			list	list
Panzhihua	ST	•					•								D				map	map
Philadelphia	ST	•			•	•	•			•						map	•	•	•	
Porto Alegre	ST																			
Quanzhou	ST	•		•	•					•						•				
Rio de Janeiro	T			•										•		•				
Rome	ST	•												•	R	map		•	map	map
Salvador de Bahia	T			•										•						
San Antonio	ST						•											•		
Santiago de Cali	T	•	•								•					map				
Tegucigalpa	T	•	•											•		list				
Tshwane	ST	•																		
Turin metro	ST	•		•										•						
Xiamen	ST				•															
Zhengzhou	ST				•			•		•										
Total		20	8	8	7	4	8	2	3	4	3	1	1	11		12	1	3	4	8

2.3.2.5 Other Plans

Master plans, sustainability or “green” plans, and local development plans that include adaptation measures converge in this group (8%). Mainstreaming adaptation within existing tools (or integration of adaptation concepts) (Levina and Tirpak

2006:15) is deemed to be the key to successful adaptation (Revi, Satterthwaite *et al.* 2014: 45; Bassett *et al.* 2010). This approach is adopted in Brazil where large municipalities act independently with their own policies and plans, which also occurs in India (Sharma *et al.* 2010) and other countries (Preston *et al.* 2011).

The main advantages of this approach should theoretically include the five items described below.

1. Low exposure to hazards after the inclusion of adaptation in land use planning (prohibition of building on land that is exposed to floods, creation of green areas to reduce the impact of heat waves) (Hyderabad).
2. Increased possibility of implementing new measures by including adaptation in the tool the local government is already carrying-out.
3. Charge the cost of mitigation to the private sector where urban extension occurs prevalently by subdivision plans (OECD countries) via including mitigation measures among the requisites a developer must meet to be authorised to develop the land (San José, CA).
4. Ensure cost reduction by optimising actions that are already either envisaged or funded in other sectors, as in the case of Millennium Development Goals for sewage devices and the adduction of drinking water.
5. Reduce the contribution of the large cities to CC when regulations on the use of construction materials (that affect albedo), building density (urban heat island) and natural ventilation are favourably modified (Alcoforado *et al.* 2010).

In practice, the cases of mainstreaming adaptation into physical planning tools for large cities present several limitations compared to climate plans. Specifically, these include lack of characterisation of the hazard, prevalence of actions that only concern land use (set back to be complied with during construction works, and land use allowed), lack of priority and scheduling, no reference to the expected impact of works, rare implementation of monitoring (Table 2.7).

2.3.3 Measures

Comparing plans by considering the measures envisaged can be misleading. When climate planning is carried out, each city does not start from the same baseline. For example, separate glass, metal, paper, and food waste and recycling programs or the use of LED bulbs for street lighting can be innovative measures used in one city, while they are so consolidated in another that they need not even be mentioned among the measures established by the plan. Hence, the absence of certain measures does not always indicate lack of detail or visionary planning. That said, we shall now discuss measures that are most frequently adopted.
The 29 climate plans of large subtropical and tropical cities traced (7 in Latin America, 7 in the USA, 7 in Middle East and Asia, 4 in Europe and 4 in Africa), one third of

Table 2.7: Large subtropical and tropical cities. Quality of climate measures in other plans.

Large city	Plan	Hazard						Measure							
		Flood	**Rain**	**Storm**	**Drought**	**Heat**	**Fire**	**Baseline**	**Prone area**	**Localization**	**Priority**	**Cost**	**Impact**	**Scheduling**	**Monitoring**
Athens	Mo											Partial			
Goiania	S	•													•
Hyderabad, IND	M	•	•		•	•				Map					
Managua	S	•						•	•		•	•		•	
Nagoya	B					•		•							
Sydney	W				•									•	
Wuhan	M	•					•								•
Total										1	1	1	0	2	2

B-Biodiversity, Mo-Mobility, MP-Master, S-Sustainability, W-Water

which were defined after 2012, concern the main jurisdiction only, with the sole exception of Miami, Montevideo and Portland, where all the metropolitan area was considered. Planning using a metropolitan scale stems from the need to harmonise the measures of many jurisdictions and authorities (water, etc.), whose consent is required (Revi, Satterthwaite *et al.* 2014: 44). Plans for metropolitan areas include building awareness, studies and assessments to ensure that mitigation/adaptation measures become rooted in each jurisdiction, and fundraising initiatives.

Municipal plans focus instead on direct impact, especially on the municipal facilities (offices, transportation, employees), and on sectors in which the Municipality has regulatory authority (private construction works, road systems, waste, education, etc.).

The 29 plans analysed contain over 100 mitigation measures and 50 adaptation measures, which we collected by area (Table 2.8). The most frequently proposed mitigation measures include low-carbon transportation (21), building adjustments to reduce the total energy use (19) and local government operations (use of LED bulbs for traffic signals, street and parks lighting, 16 plans). The above are closely followed by waste reuse/recycling to recover gases emitted by landfills and wastewater treatment plants (15), and information and communication measures (15).

Table 2.8: Large subtropical and tropical cities. Measures in 28 climate plans by sector. The numbers indicate the number of measures proposed in every sector.

Measure sector	Adelaide 2011	Antalya 2013	Baires 2009	Bangkok 2007	Barcelona 2010	Cape Town 2011	Cartagena 2013	Casablanca 2011	Durban 2010	Ganziantep 2011	Guayaquil 2012	Houston 2008	Los Angeles 2007	Marseille 2012	Miami 2008	Milan 2009	Montevideo 2012	New York City 2013	Philadelphia 2007	Phoenix 2009	Portland 2009	Rome 2010	Saitama 2012	Santiago Chile 2012	São Paulo 2011	Tbilisi 2011	Tunis 2011	Zapopan 2013	All plans
Mitigation																													
Energy, efficiency	1	8	3	3	2	2				2		3		2	2	24	1			2	8	16	1	1	1	1		2	20
Building, green	2	8	3		14	4		1		3		2		1	4	9	1		10		9	2	4	3		10	1		19
Water, reducing consumption	2	1				1		1		2		2	1												2		1	1	10
Fuel, clean		3	1	2		1						1	4		2					2					1				9
Transport	1	5	3	5	18	2				1	2	2	1	7	4	12			7	2	6	8	2		5	8		1	21
Waste, reuse/ recycling	1	3	3	3	3					2	2		1	5		1			5	2	13				3			2	15
Food, organic, bio														1							6				2				3
Agriculture														1		2								1				1	4
Land use		3		1		1	1					1	3	1					2				2		1				10
Information/ communication	1	3	1			1	1	1			1		1		1				4		6		4	2	1			2	15
Funding projects														3															1
Monitoring														2															1
Adaptation																													
Knowledge and studies			2			2	4	13	3	1	1		1	4			5	6						2	2		6		14
Preparedness																		13											1
Built environ-ment	1								3		1		2				3	14							1			1	8
Water conservation	1							2					1		2									1	1		1	1	8
Drainage			1				1	4	1															1			4		6
Utilities																		47											1

continued **Table 2.8:** Large subtropical and tropical cities. Measures in 28 climate plans by sector. The numbers indicate the number of measures proposed in every sector.

Measure sector	**Adelaide 2011**	**Antalya 2013**	**Baires 2009**	**Bangkok 2007**	**Barcelona 2010**	**Cape Town 2011**	**Cartagena 2013**	**Casablanca 2011**	**Durban 2010**	**Ganziantep 2011**	**Guayaquil 2012**	**Houston 2008**	**Los Angeles 2007**	**Marseille 2012**	**Miami 2008**	**Milan 2009**	**Montevideo 2012**	**New York City 2013**	**Philadelphia 2007**	**Phoenix 2009**	**Portland 2009**	**Rome 2010**	**Saitama 2012**	**Santiago Chile 2012**	**São Paulo 2011**	**Tbilisi 2011**	**Tunis 2011**	**Zapopan 2013**	**All plans**
Coastal protection						1	1		1								2	37											5
Green extension/managem.	1		1	1			1				2		3		1			16						2	2			3	11
Health									2									38											2
Insurance																	1	16											2
Total measures	10	34	18	13	37	15	9	22	10	11	9	11	18	27	16	28	13	195	28	8	48	24	26	14	22	19	13	15	-

To reduce energy consumption, actions must also target the physical structure of the city by enhancing compactness, concentrating activities on certain points or axes to reduce the per capita daily vehicle-miles traveled, and by making the mass transportation system economically sustainable. But investments must also focus on work organisation (telecommuting, flexible work hours). These measures, which were conceived by a city to be elite until a few years ago, are now practised at all latitudes (land use, 10 plans). However, significant changes in the physical and functional structure of the city requires years, if not decades, to be implemented. Meanwhile workers and activities become suburbanised, and the working mode undergoes changes (having two jobs is a common practice for many residents), thus removing the effects of the reformed physical structure on per capita daily vehicle-miles traveled.

Adaptation measures depend on the hazard. Studies have the highest incidence of use (14), followed by green extension (11), which was conceived to limit run-off and urban heat island. Water conservation and built environment follow closely (each with 8), and also stormwater drainage maintenance (6). (Table 2.8)

It must be said that only in two cases was insurance deemed an adaptation measure. There are two possible explanations for this. Firstly, the insurance sector is already highly developed and does not deserve to be mentioned as a measure in cities governed by OECD economies. Secondly, the opposite situation is found in the less developed economies, but there are a few private enterprises that wish to protect their own interests.

Resilience measures are primarily structural (55%), and especially concern the water sector. Non-structural measures are substantial, regardless (45%), and concern community awareness, training, early warning, studies, assessments and plans.

The analysis of 33 climate plans (Table 2.3) emphasizes the fact that half of them neither specify the impact of mitigation (MT CO_2/year) or of adaptation, nor the costs resulting from lack of mitigation and adaptation. Hence, it is hard to assess the benefit that can be obtained by implementing the single measures net of mitigation/adaptation costs. This is why preliminary risk mapping is required to highlight the hot spots that need priority intervention (Tiepolo and Braccio 2015, chap. 11).

Moreover, there are substantial differences between subtropical and tropical cities regarding measures. To understand this, we must not forget that we prevalently find large cities of Developing Countries in tropical zones. Firstly, the climate plans of subtropical cities contain three-fold the measures of tropical cities. They are complex plans with many arrows to strike the targets. Secondly, in large subtropical cities measures focus on modernising building assets (ecological roofs, passive cooling, energy efficiency) and infrastructures to reduce the consumption of power and water (Adelaide, Casablanca, Santiago, Tunis). Instead, in large tropical cities measures focus on increasing consumption, taking into account the lack of sanitation, rainstorm drainage, adduction of drinking water, and removal of solid waste in many districts (Cartagena, Guayaquil).

2.3.4 Quality of Climate Planning

Several parameters, such as internal consistency between objectives, priorities and measures (Baker *et al.* 2012) can be considered to assess the quality of plans. In our case, we are interested in assessing the implementation features of planning tools. Specifically, if they are able, as currently formulated, to guide the implementation of measures that reduce the impact of CC. The focus will then be on six indicators: (i) climate characterisation, (ii) funding for planning, (iii) cost of measures, (iv) responsibility for each measure, (v) funding sources, (vi) implementation monitoring and reporting.

2.3.4.1 Climate Characterisation

Effective climate characterisation allows for improved definition of the measures. Mitigation plans do not analyse the climate but rather estimate GHG emissions according the sectors that generate them, specifically transportation, commercial, industrial, residential and waste. This helps to define emission-reducing measures. The major part of plans describes the possible future scenarios, taking into account the increased energy demand (transportation), population increase, changes in water consumption (water, solid waste) and changes in environmental parameters. Instead, adaptation plans and, at times, resilience strategies characterise the climate. They consider the main environmental parameters (temperature, precipitation, sea level, wind, sea waves), and define climate events and extremes variability, which helps to identify possible measures to reduce vulnerability. About 90% of adaptation plans provide estimates of long-term future trends (2030, 2050, 2100) for each of the environmental parameters analysed. These estimates are obtained by using both global and regional climate models. Different models are usually used, up to 21 in the case of Barcelona and 9 in the case of Surat. Plans that report the results of climate analysis mention the following long-term trends (Table 2.9):

- temperature increase from 0.5–1.5°C by 2030 and up to 4–5°C by 2090;
- increase in heat waves both in terms of number and duration (two-fold and even three-fold);
- drop in the number of rainy days without a significant trend in annual accumulated precipitation;
- increased incidence and intensity of extreme rainfall events (both likelihood of flash floods and/or more intense monsoons);
- increase in sea level rise (15 to 79 cm by 2030–2050).

Not even emergency/contingency plans characterise the climate because they are implemented after an alert is issued by a specialised centre. In some cases (Hyderabad, Luoyang, Milan, Panzhihua, Rome, Turin), the plan specifies the threshold that triggers the various types of alert, which can be mm of rain within a period of time (surface flood), cm reached at the water level gauge (river flood), cm of snow (avalanches), number of consecutive days without rainfall (drought), or temperatures above the maximum seasonal average (heat waves). The other plans do not characterise the climate.

Hence, the plans present two limitations in terms of climate analysis. Firstly, they do not define the probability of concurrent occurrence of different types of hazards, for instance coincidental floods due to a sea level rise, surface flood or river flood. Past disasters indicate that such a circumstance generates catastrophic consequences (e.g. Venice 1966).

Secondly, they do not define the geographic origin of the floods that affect large cities, as already observed regarding sub-Saharan cities (Tiepolo 2014a). Some river floods are determined by changed patterns of rainfall in areas that are distant from cities, at times even in other countries, and can determine non-seasonal catastrophic floods. These analyses, especially if they concern border zones, should start by defining the watersheds of the tributaries of the river that crosses the large city concerned. Daily rainfall recorded by ground-based weather stations situated in other countries generally cannot be easily accessed by the large city concerned. However, the analysis can be conducted by the national weather service by using data on daily precipitations as estimated by satellites, even for neighbouring countries, by exploiting the dedicated regional information systems (e.g. EMSAT MSPE for West Africa). Knowing the full extent of the watershed responsible for river floods in large cities is essential to schedule and coordinate adaptation measures.

Table 2.9: Large subtropical and tropical cities. Climate characterisation in 12 adaptation plans.

Large city	Sea level rise	Pecipitations	River flow Peak discharge increase	Temperature			UAI	Bush fire weather increase	Air quality	Return period	Models	Climate projections
	cm	Trend or mm/Y	%	Min °C	Max °C	Extrm %	°C or %	%			n.	
Adelaide	–					35		20				2030
Barcelona		reduction		2.2	5.1				PM10 NO_2		21	2080–2099
Buenos Aires	60				0.5							2020–2029
Cartagena	15–20	Ext. increase										2040–2050
Casablanca	20	reduction		0.8	1.3					•		2030
Durban	rise				rise							2045–2065
Ho Chi Minh	•			1								2050–2100
Indore	–	increase	50–80	2			2–4				1	2021–2100
Johannesburg		+18–27%		2.5	2.3							2046–2100
Los Angeles							double		78–85%			2100
New York C	28–79	+4–13%					100–200	–				2020–2050
Santiago Chile		reduction		1–2	1–2							2045–2065
Surat	–	200–450			4						9	2070–2100

2.3.4.2 Financing Climate Planning

The process for preparing the plan in OECD countries is funded by municipal resources in 80% of cases, in BRICS in 40% and in Developing Countries, 33%. Hence, climate planning is almost always funded by development aid in the tropics (Table 2.10), which means that it is a gift. "Gifted" plans are increasing in Developing Countries in recent years. This practice weakens planning because it undermines local appropriation of tools. If we also consider plans that, at times, are not drawn up in compliance with a law that prescribes them, this explains why they often have poor operative features.

Table 2.10: Large subtropical and tropical cities. Origin of resources used to draw up 37 climate plans.

Country group	National	Municipal	Multi-bilateral development aid	Mixed	Total
OECD	1	15	1	1	18
BRICS		2	3	0	5
Other		5	9	0	14
Total	1	22	13	1	37

2.3.4.3 Assessing the Cost of Measures

Fifty-six percent of the plans specify the cost of measures, but unfortunately, only too often said calculation is only carried out for some of them (Buenos Aires, Casablanca, Gaziantep, Milan, Montevideo). Amounts vary considerably when the cost is estimated, depending on the nature of the envisaged measures, on the dimensions of the city, and on the calculation method (annual or global). The per capita cost is the best way to compare plans. It can vary from 3 (Phoenix) to 2,378 US$ (New York City) (Table 2.11). Climate plans for the cities in tropical Developing Countries do not report the costs of measures; hence, they run the risk of not being implemented.

2.3.4.4 Identifying Responsibility for Each Measure

A measure without a clear owner is destined to fail. 52% of the plans identify the municipal office responsible for the implementation of each measure (Table 2.11). Among these plans, only one is for tropical cities.

2.3.4.5 Funding for Climate Measures

39% of plans specify the funding source envisaged for the measures. But often the sources of funds are only roughly indicated (Cape Town, Casablanca, Montevideo,

Table 2.11: Large subtropical and tropical cities. Quality indicators of 27 climate plans.

Large city	Quality indicator					
	Climate characterization	**Municipal funding of plan**	**Measure cost**	**Measure implementation responsible**	**Funding sources**	**Monitoring**	**Total**
Adelaide	1	1				1	3
Antalya		1	1	1			3
Bangkok							0
Barcelona	1	1	1		1		4
Buenos Aires	1	1	1				3
Cape Town		1			1		2
Caratgena	1						1
Casablanca			1	1			2
Durban	1	1		1			3
Gaziantep		1	1	1		1	4
Guayaquil		1					1
Houston		1		1			2
Johannesburg	1	1		1			3
Los Angeles	1	1					2
Marseille		1	1			1	3
Miami		1	1	1	1	1	5
Milan city		1	1	1		1	4
Montevideo		1	1		1		3
New York City	1	1	1	1	1	1	6
Philadelphia		1		1			2
Phoenix		1	1		1		3
Portland		1	1		1	1	4
Rome city		1	1	1	1	1	5
Santiago Chile	1	1		1	1		4
São Paulo		1				1	2
Tbilisi		1	1	1			3
Tunis			1	1	1		3

*Permit fees, tolls, traffic fines. *minimum

Tunis) (Table 2.11). Conversely, some plans present detailed costs and specify how they will be covered (Miami, New York, Phoenix). When the costs are not known, it is impossible to assess the efficiency of adaptation (Adger *et al.* 2005). Funding sources are clearly broader in subtropical zones where local governments not only depend on their own resources (fees, fines, tolls), but also on credit, municipal bonds, project financing, and on the contribution of regional/state and federal/national governments. Plans for large cities in tropical Developing Countries do not specify the funding sources of the measures, which is another factor that undermines their implementation.

Implementation of measures can be assigned to private parties in seven ways.

The first is to issue building authorisations only on condition that the developer will implement mitigation measures, some of which were typical of the visionaries of bioclimatic architecture in the 1970s (Mazria 1979; Vale and Vale 1980): from screening buildings with deciduous trees planted near building roofs, to fenestration limited at 40% of the façade surface, composting sites, solar panels, cool roofs, renewable energy systems (solar, wind turbine), the majority of windows facing South, and recycled water systems (San José, CA). The second is the carbon-based adaptation fee. The tax is based on the "polluter pays principle", and serves to fund the adaptation measures and encourage polluting companies to reduce emissions (Kaoshiung). The third is the issuing of catastrophe bonds (Florida, Mexico), which have been recently supported by the World Bank through MultiCat (ICLEI 2011). The fourth is a property and casualty insurance surcharge as proposed by New York City. The fifth is implementation of a mitigation banking programme (New York City) (Zirschky *et al.* 1995). This system consists of authorising construction works on wetlands after developers purchase mitigation credits to pay a third party that implements protection/restoration of environmentally important coastal wetlands. The sixth is involvement of private enterprises through project financing (Rome). Finally, the literature reports a funding mode we found no trace of in the plans considered, namely microfinancing. This option addresses individuals, and cannot be used to implement community works, such as drainage canals or dams. But it would allow for making houses climate-proof (Revi, Satterthwaite *et al.* 2014) and supporting small entrepreneurs who usually have no access to either insurance or formal credit.

The ones mentioned by way of example do not constitute universally effective solutions. Three out of four large cities do not expand in compliance with building/urban regulations, but rather through informal settlements, and potential payers of the carbon-based adaptation fee are few. In such cases we must not forget that the large cities of developing countries, including LDCs, regardless contain valuable assets, such as vacant land with infrastructures. Improving local fiscal systems, activating value capture, and taxing vacant lands (McCarney 2012) can provide sufficient resources to implement measures that reduce the impact of CC in hot spots (Braccio *et al.* 2014).

2.3.4.6 Monitoring and Reporting

The monitoring and reporting program allows for checking progress in the implementation of the plan, assessing it, and communicating the results to both decision-makers and local actors. The literature reports that plans are rarely monitored (Revi, Sattertwhaite *et al* 2014: 59). Our survey on plans, one third of which were very recent, defines a less pessimistic picture. The monitoring device (of measures or of GHG emissions) is envisaged by 10 plans (33%), and 4 plans out of 27 envisage reporting (Table 2.3). However, the program is often only stated and not described in detail (Milan). And even in the latter case, it presents several omissions compared to the conventional Monitoring and evaluation criteria (Tiepolo 2012), precisely the crucial ones concerning the indicators to be used for monitoring, the methods and costs of information collection, monitoring phases, and assessment methods for the impact of the plan, all of which are the target of the reporting process. Once again, climate plans for large cities in tropical Developing Countries stand out for the lack of monitoring and reporting.

2.4 Conclusions

The objective of this chapter was to ascertain the relevance and quality of climate planning. We limited the analysis to large cities in the subtropics and tropics, zones that, regardless, contain half the urban population of the World.

Our survey presents three innovative features compared to previous ones, because (i) it considers the cities by climate zone and dimension, (ii) it analyses the relevance of plans for the number of cities in the segment concerned, taking into account the hydro-meteorological and climate-related disasters and, finally, (iii) it assesses planning quality.

We found that barely a quarter of the large cities in the subtropics and tropics has a climate plan. The percentage is low, if we consider the extensive, greater than ten-year long commitment of multilateral bodies, central and local governments to face CC. Emergency planning is the most common type. It is followed by mitigation plans and, far below in terms of frequency, by adaptation plans and resilience strategies. Other types of plans (sustainability, master plans) are a minority.

The analysis by climate zone revealed aspects that were not highlighted by previous surveys. The tropics differ from the subtropics in the type of hydro-meteorological and climate disasters (no drought, more extreme rains), quantity of per capita GHG emissions (less), local government skills (poor planning), and expansion mode of the cities (informal). Planning measures, especially mitigation ones, change from zone to zone because they consider these differences. Climate zone characterisation also depends on the standard of economic development that prevails in the site. The subtropics include OECD and BRICS nations, while Developing Countries and, especially, Least Developed Countries, prevail in the tropics.

The status of planning outlined so far is steadily evolving. During the past five years, the number of large cities that have a climate plan has increased by 150% compared to 2010. Unfortunately only one fourth of the new plans concern cities in Developing Countries. In particular, none of the 20 large cities in LDCs has a plan, though this group has been repeatedly affected by hydro-meteorological and climate-related disasters. Development aid, which by definition funds half the plans, does not intervene in these cities, not even to co-fund the planning process, which would be more sustainable than the gift if the scope were to guarantee appropriation of the plans.

Some supranational initiatives, such as the Covenant of Mayors, have greatly contributed to disseminate climate planning, standardize its features, and improve its quality. However, 70% of plans attend 3 or less indicators out of the six chosen to gauge quality.

These results are useful for the discussion on Sustainable Development Goals. In the first place, they reveal that the substantial participation of large cities in the associations that promote climate planning does not correspond to an equal number of climate plans. Secondly, the results of our analysis confirm that the trend to support LDCs in reducing the number of affected cities and damages caused by hydrological disasters meets a genuine need that international communities have been unable to meet thus far.

There remains the issue of extending mitigation/adaptation/resilience planning to 75% of large cities that still lack it, and of studying improvement modes for existing plans. Some experts propose learning from the cities that adapted first. The considerable differences between cities classified by climate zone and economy of origin suggest that extreme caution is required before this proposal can be accepted. Promoting climate planning in the sub-Saharan region, based on the Covenant of Mayors model, might instead be the solution, especially if the process of drawing up plans is considered a prerequisite to access multi-bilateral co-funds for the implementation of climate measures.

2.5 Recommendations

The literature and plans we have referred to are deficient, if not silent, regarding eight factors, and we recommend that experts explore these points:

1. state of climate planning in middle-sized cities. The number of subtropical and tropical cities between 0.1 and 1 million inhabitants is over 2,200. The climate planning survey presented in this chapter should be replicated for this important class of cities, which have documented various climate plans since 2003.
2. analysis of GHG emissions relative to city size. This analysis offers a wealth of implications for physical planners. It is important to verify whether the absence of direct relations between per capita GHG emissions and city size ascertained for large cities also applies to middle-sized cities: it might enrich the ongoing debate

on optimal city size with an environmental consideration. In the first place, the analysis of GHG inventories must be extended to medium-sized cities and, later, data must be reanalysed when GHG inventories based on the new post-COP20 standards become available.

We advise local governments and their partners to strengthen or define five points.
1. Urban characterisation of CC. The probability of a coincidental hazard and the geographical origin of events that determine catastrophic river floods can enhance the implementation of adaptation measures. Information on peak temperature, humidity, and direction of dominant winds are useful for planners to establish the direction of road network, building density, and location of green spaces in order to better adapt to the climate.
2. Local planning skills. It is an ingredient without which mitigation/adaptation cannot succeed. There are three essential steps. First, arrange the tools (GIS for risk assessment) and data on previous disasters. Second, acquire working skills in multidisciplinary teams. Meteorological services must collaborate with physical planners, hydraulic engineers, NGOs and CBOs, and with producers of scientific information and knowledge (Gagnon-Lebrun *et al.* 2006), and all these must cooperate with municipal planning bodies, professional planners and decision-makers (Bassett *et al.* 2010). Third, adapting best practices to local specifications. These steps characterise local capabilities, which should be assessed during planning and supported by dedicated measures if one actually wishes to produce local operative planning.
3. Plans for the metropolitan area. Climate planning is almost always limited to the main jurisdiction. Preliminary risk maps are required, and measures must be planned on a metropolitan scale.
4. Priority intervention zones. They are often not defined in the plans, and they cannot be defined with means, times and information as in EU28 after the definition of Directive 2007 on flood risk mapping. Snapshot tools as a means of preliminary risk assessment seem more sustainable and feasible for appropriation by local bodies. However, a definition of risk (Risk = Hazard * Damage) that allows for measuring the single components is required to produce preliminary risk maps.
5. Funding the established measures. A mitigation plan can be funded by requiring compliance with some requisites to issue building authorisations or a ‘polluter pays principle’ where private individuals have resources and where there is a significant number of industrial companies (OECD, BRICS). Mitigation banking, needs organisation, and law changes. Adaptation can be funded with catastrophe bonds and project financing. But in the other cities, it is essential to reformulate local taxes.

We advise multilateral development agencies to support:

1. climate planning South of Sahara. The example of the Covenant of Mayors, progressively broadened by the EU28 to North Africa and to the Middle-East, should be proposed again to benefit large continental cities. The issuance of funds for planning measures should be subordinated to the adoption of plans on the subject.

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Appendix A

Mitigation, Adaptation, Resilience, Strategy, Policies and Plans

Adelaide city council (2013) Climate change adaptation action plan 2011–2013
Greater Antalya Municipality (2013), Antalya green house inventory and sustainable energy action plan
Ajuntamento de Barcelona (2010) Plan de energía, cambio climatico y calidad del aire de Barcelona (PECQ 2011–2020)
Bangkok metropolitan administration (2007) Action plan on global warming mitigation 2007–2012
Prefeitura de Belo Horizonte (2013) Plano de redução de emissões de gases de efeito estufa PREGEE. Relatório técnico final
Prefeitura Municipal de Belo Horizonte (2011) Política municipal de mitigação dos efeitos da mudança climática
Buenos Aires (-) Cambio climático. Plan de acción Buens Aires 2030
Can Tho City People's Committee, Steering Commitee for Decision 158 (2010) Can Tho city climate change resilience plan
Egis BCEOM International/IAU-IDF/BRGM (2011) Plan d'adaptation et de résilience du Grand Casablanca. Rapport final
Chongqiong Municipality (2007) Energy saving
Invemar, MADS, Alcaldia Mayor de Cartagena de Indias-CDKN (2012) Lineamentos para la adaptacion al cambio climatico de Cartagena de Indias
Ethkwini Municipality (2013) Durban climate change strategy. Draft vision statement
Ethkwini Municipality (-) Climate change adaptation planning for a resilient city
Gaziantep (2011) Climate action plan of Gaziantep Energy and gereenhouse gas emission profile preliminary action plan and implementation strategy. Final report rev 2
VCAPS Consortium (2013) Climate adaptation strategy Ho Chi Minh City. Moving towards the sea with climate change adaptation
Guangzhou (-) Energy saving and reduction of pollution gas plan
Municipalidad de Guayaquil (2013), Decalogo de acciones de Guayaquil frente al cambio climatico, y proyectos de desarollo sostenible
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City of Houston (2008) Emission reduction plan
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City of Kobe (2011) Climate and environmental plan
Lagos state government (2012) Climate change policy 2012–2014
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Comune di Milano (2009), Piano d'azione per l'energia sostenibile e il clima
PNUD (2012) Plan climatico de la region metropolitana de Uruguay
City of Nagoya (2008) Nagoya biodiversity strategy
Comune di Napoli (2012) Piano d'azione per l'energia sostenibile
City of New York (2013) A stronger, more resilient New York
City of Philadelphia (2007) Local action plan for climate change
City of Phoenix (2009) Climate action plan for government operations
City of Portland and Multnomah county (2009) Climate action plan 2009

Quingdao Municipality (2012) Energy saving and reduction of pollution gas plan
Cidade do Recife (2014) Política de sustentabilidade e de enfrentamento das mudanças climáticas do Recife e dá outras providências
Prefeitura da cidade do Rio de Janeiro (2015) Rio resiliente Diagnóstico e áreas de foco
Roma capitale (2010) Piano d'azione per l'energia sostenibile della città di Roma
Saitama prefecture (2009) Stop global warming. Saitama navigation 2050. Saitama Prefecture global warming strategy action plan
City of San José (2011) Greenhouse gas reduction strategy for the city of San José
Gobierno regional metropolitano de Santiago (2012) Plan de adaptación al cambio climatico para la región metropolitana de Santiago de Chile
Prefeitura da cidade de São Paulo (2011) Plano de ação para mitigação e adaptação da cidade de São Paulo às mudanças climáticas, comitê municipal de mudanças do clima e eco economia e seus grupos de trabalho
City of Semarang (2010) Semarang's adaptation plan in responding to climate change, ACCCRN
Shenzhen Municipality (2014) Energy saving
Republic of Singapore, National climate change secretariat (2012), National climate change strategy 2012
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City of Yokohama (2008) Yokohama climate change action plan
Municipio de Zapopan (2013) Plan de acción climatica municipal de Zapopan

Other Plans

South East Europe Mobility management scheme (2010) Mobility management plan for the city of Athens 2010–2014
Prefeitura municipal de Goiânia (2012) Goiânia sustenável. Plan de ação
Hyderabad Metropolitan Development Authority (2013) Metropolitan development plan for 2031
Kobe City (2011) Climate and environmental basic plan
Alcaldia de Managua (2013) Plan de acción Managua sostenible
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City of Wuhan (2010) Wuhan urban master plan

Emergency Plans

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Governo do Estado de São Paulo (2014) Normas de procedimientos do Plano de contingência para o periodo de estiagem da Região metropolitana de Campinas
Cape Town (2012) Municipal disaster risk management plan
Chongqiuong Municipality (2008) Disaster emergency salvation

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Dongguan Municipality (2004) Disaster emergency response
Fukuoka city disaster prevention council (2012) Fukuoka regional climate prevention
Guangzhou Municipality (2013) Disaster of Tsunami and surge emergency response
City of Jinan (2012) Jinan city flood emergency plan
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District disaster Management Authority (East) (…) District disaster management plan East Delhi
Emergency Support Unit Security Bureau Government Secretariat (2007) Hong Kong Contingency plan for natural disasters (including those arising from severe weather conditions)
Hyderabad City (2009) Flood emergency rain relief plan 2009
Municipalidad metropolitana de Lima, Region de Callao (2011) Plan de operaciones de emergencia para el área metropolitana de Lima y la región de Callao
Luoyang's Municipal people government office (2013) Luoyang city flood emergency plan
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City of Panzhihua (2008), Panzhihua city flood control and drough contingency plans, Office of emergency management
Municipio de Porto Alegre (1998) Plano de defesa civil
Quanzhou City people's government office (2012) Quanzhou natural disaster relief emergency plan (revised)
Prefeitura Rio Defensa civil Rio de Janeiro (2014) PEM Rio Plano de emergência para chuvas fortes da cidade do Rio de Janeiro
Comune di Roma (2008) Piano generale di emergenza di protezione civile
City of San Antonio (2013) Drought operations plan
Prefeitura municipal do Salvador (2013) Defesa civil. Plano de contingência para chuvas 2013
Municipio de Santiago de Cali (2009) Plan local de emergencia y contingencia PLEC
Shanghai Municipality (2009) Disaster emergency response
Shenzhen Municipality (2014) Gas pollution emergency response
Shenzhen Municipal bureau of meteorology (2011) Shenzhen meteorological development 12th five years plan
Tangshan city government (2007) Tangshan forest fire emergency plan
Municipio del Distrito Central, Comité de emergencia municipal (2007) Plan municipal de emergencias, Tegucigalpa, MDC
Provincia di Torino (2013) Schema di piano provinciale di emergenza di protezione civile
City of Tshwane (2007) Disaster risk management plan Level 1
Xiamen (2010) Xiamen anti-typhoon emergency plan
Municipal flood control and drought prevention of Zhangjiagang city (2012) Zhangijagang city flood emergency plan
Zhengzhou municipal people's government office (2011) Zhengzhou city meteorological disaster contingency plan

Appendix B – Subtropics and Tropics, 2015. 82 Large Cities Provided by Climate Planning

Large city (over 1 M P)	Country ISO 3166-1	Zone	P millions	Planning tool	Year
Adelaide city	AUS	ST	1.3	A	2011
Ahmedabad	IND	T	6.3	E	2012
Antalya	TUR	ST	1.0	M	2013
Athens	GRC	ST	3.1	O	2010
Baires municipality	ARG	ST	2.9	AM	2009
Bangkok	THA	T	8.2	M	2007
Barcelona	ESP	ST	1.6	M	2010
Bazhong	CHN	ST	3.3	E	2009
Belo Horizonte	BRA	T	2.5	SP, M	2011, 2013
Campinas	BRA	ST	1.1	E	2014
Can Tho	VNM	T	1.2	R	2010
Cape Town	ZAF	ST	3.5	E	2011/12
Cartagena	COL	T	1.0	A	2013
Casablanca	MAR	ST	2.9	A	2011
Chongquing	CHN	ST	17.2	M	2007/08
Delhi	IND	T	19.0	E	2015
Dallas city	USA	ST	1.3	E	2014
Dongguan	CHN	ST	8.7	E	2004
Durban	ZAF	ST	3.4	S	2010
Fukuoka	JPN	ST	1.5	E	2012
Gaziantep	TUR	ST	1.5	M	2011
Goiania	BRA	T	1.3	O	2012
Guangzhou	CHN	ST	12.7	E	2013
Guayaquil	ECU	T	2.3	A	2012
Ho Chi Minh city	VNM	T	8.2	S	2013
Hong Kong	CHN	ST	7.1	E	2007, 2010
Houston city	USA	ST	2.2	M	2008
Hyderabad metro	IND	T	6.8	O	2013
Hyderabad	PAK	T	1.1	E	2009
Indore	IND	T	1.9	S	2012
Jinan	CHN	ST	6.8	E	2012
Karachi	PAK	T	23.0	S	2012
Kobe	JPN	ST	4.1	O	2011
Lagos	NGA	T	9.0	P	2012
Lima	PER	T	8.5	E	2011
Los Angeles city	USA	ST	3.9	M	2007
Luoyang	CHN	ST	6.5	E	2013
Managua	NIC	T	1.3	O	2013
Marseille	FRA	ST	1.2	M	2012
Miami county	USA	T	2.6	M	2008
Milan city, metro	ITA	ST	1.3, 3.9	M	2009, 2013
Montevideo	URY	ST	1.7	M	2012

Mumbai	IND	ST	12.5	E	2007
Nagoya	JPN	ST	8.9	O	2008
Nanchang	CHN	ST	5.1	E	2011
Nanjing	CHN	ST	8.2	E	2013
Naples city	ITA	ST	1.0	E, M	2012
New York city	USA	ST	8.2	AM	2013
Panzhihua	CHN	ST	1,2	E	2008
Philadelphia city	USA	ST	1.5	M	2007
Phoenix city	USA	T	1.5	M	2009
Portland & Multnomah	USA	ST	1.4	M	2009
Porto Alégre	BRA	ST	1.5	E	1998
Quangzhou	CHN	ST	1.2	E	2012
Recife	BRA	T	1.6	P	2014
Rio de Janeiro	BRA	T	10.0	E, R	2014, 2015
Rome city	ITA	ST	2.6	E, M	2008, 2010
Saitama	JPN	ST	1.2	M	2009
Salvador de Bahia	BRA	T	2.7	E	2013
San Antonio city	USA	ST	1.4	E	2013
San José city	USA	ST	1.0	M	2011
Santiago de Cali	COL	T	2.1	E	2009
Santiago de Chile	CHL	ST	6.1	A	2012
São Paulo municipality	BRA	ST	11.2	AM	2011
Semaarang	IDN	T	1.6	A	2010
Shanghai	CHN	ST	22.3	E	2010/09
Shenzhen	CHN	T	10.4	E	2012
Singapore	SGP	T	3.8	M	2012
Surat	IND	T	4.8	S	2011
Sydney metro area	AUS	ST	4.6	O	2010
Tegucigalpa	HND	T	1.2	E	2007
Tbilisi	GEO	ST	1.2	M	2011
Tokyo	JPN	ST	8.9	S	2007
Tshwane	ZAF	ST	2.9	E	2007
Tunis	TUN	ST	4.0	A	2011
Turin metro area	ITA	ST	2.2	E	2013
Wuhan	CHN	ST	9.8	O	2010
Xiamen	CHN	ST	1.9	E	2010
Yokohama	JPN	ST	…	S	2008
Zapopan	JPN	ST	1.6	AM	2013
Zhangjiagang	Chi	ST	1.2	E	
Zhengzhou	CHN	ST	4.3	E	2011

A–Adaptation plan, E–Emergency/contingency plan, M–Mitigation plan, O–Other plan, P–Policy or Program, R–Resilience plan, S–Strategy, ST-–Subtropical, T–Tropical.